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Market deployment strategies for photovoltaics: an international review

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Abstract

In the last decade of the 20th century a wide variety of deployment strategies and dissemination programmes for grid-connected PV systems in the built environment has been launched by quite different organizations and institutions. Governmental bodies on national and local levels have launched strategies, as have electric utilities and NGOs. The core objective of this paper is to document and evaluate the most important past and current market deployment strategies for the broader dissemination of grid-connected PV systems in the built environment.

Keywords: Photovoltaics; Strategies; National policies

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1. Introduction

In the last decade of the 20th century the market penetration of PV has been increased tremendously worldwide. While in 1990 there were mainly stand-alone systems in remote areas and the application for communication and consumer products were prevailing at the end of the decade small decentralised grid-connected systems (SGCS) became dominant by the end of 2001, see Fig. 1. This development was brought about by means of a wide variety of promotion strategies and dissemination programmes. Of special interest is that these initiatives were launched by quite different organizations and institutions. Governmental bodies on national and on local levels have launched strategies as well as electric utilities and NGOs.

The core objective of this paper is to document and evaluate the most important past and current market deployment strategies for the broader dissemination of grid-connected PV systems in the built environment[1]. Of course, most interesting are programmes from which some lessons learned are already available.

[1] Most of the work presented in this paper has been conducted in Task 7 'Photovoltaics in the built environment' within the IEA-PVPS programme. More details of this work are compiled in Haas [5, 20].

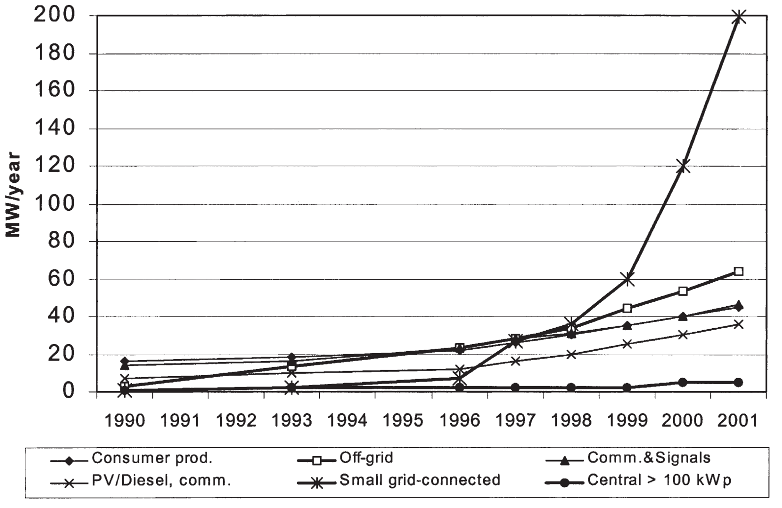


Fig. 1. The development of the PV world market by product category and the relevance of SGCS 1990–2001 (source: [16]).

The literature on strategies for PV has increased in recent years. Nordmann [21] analyzes successful solar marketing and financing strategies. Rezzonico and Nowak [1] compare buy-back rates and other promotional instruments for PV in 18 IEA countries. Haas [2] analyzes the relevance of non-technical issues for a broader market penetration of residential PV systems. Watt [3] discusses the prospects for Australia. Groenendal et al. [4] analyse critical success factors for a large-scale introduction of grid-connected PV systems.

Strategies for a broader market penetration of a technology usually focus on the following criteria:

- improvement of the economic viability (identifying added economic values, reducing system costs);
- information on the wider advantages of a product of its values added; e.g. environmental benignness;
- increasing the technical performance;
- enhancing the social acceptance.

Fig. 2 depicts the yearly installed PV capacity per capita in various OECD countries up to now. It can clearly be seen that the most successful countries are those with the most ambitious programmes: Switzerland, Japan and Germany, or where off-grid PV is cost-effective: Australia.

In the next section a basic survey on various types and features of strategies is provided and the suitability of various strategies with respect to removing different barriers addressing various target groups are described.

In the following chapters for the most important types of strategies examples are documented with respect to programmes which are currently or have in the past been

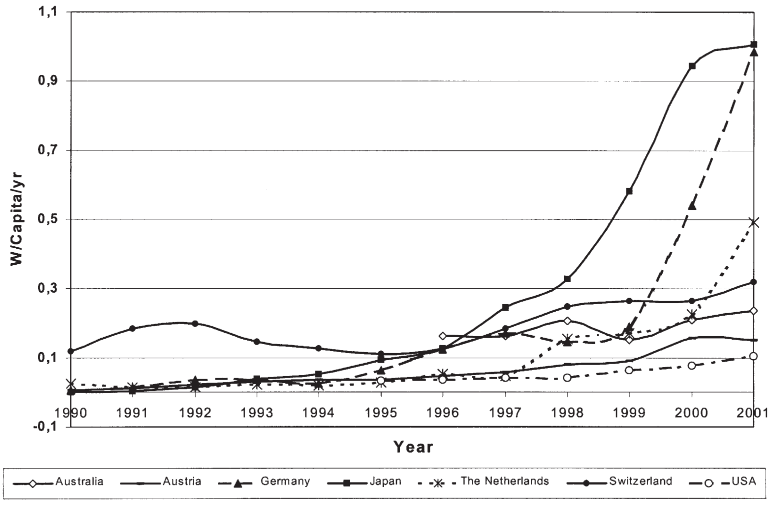


Fig. 2. Yearly installed PV capacity per capita over time in various countries 1990–2001 (source: IEA-PVPS, 2002, [16]).

implemented in different countries. Major emphasis is put on programmes from which lessons learned are available and less focus is on programmes which have been announced only recently.

Finally, the different strategies are evaluated and the most important conclusions are derived.

2. Types and features of dissemination strategies

Next it is of interest whether and how the speed of market penetration of PV can be accelerated. This is done by applying proper dissemination strategies.

2.1. Objectives of strategies

The *major objectives* of strategies are:

- to remove the barriers for a broader market penetration;
- to increase the capacity installed and the market penetration of PV;
- to enjoy the corresponding environmental benefits;
- to exhaust customers WTP;
- to increase social acceptance and public awareness;
- to reduce costs per kWh generated;
- to improve technical reliability, technical performance and standardization;
- to lead to sustainable growth of the PV industry.

In recent years a wide variety of dissemination strategies have been implemented

in various OECD countries. In the following the major features/dimensions of dissemination strategies are described. Next, a survey on which types of promotion strategies exist in principle and how they work is provided.

How these strategies are put into real life by means of specific programmes in certain areas or countries is depicted in the following chapters. Different types of programmes in these various strategy categories which are currently or have in the past been implemented in different countries are described in the following chapters.

2.2. Survey: which strategies exist in principle?

Next it is analysed which strategies exist in principle and how these strategies can be classified systematically. In this context the following questions are of interest:

- Who launches a strategy? Governments? NGO's? Commercial companies, e.g. 'Green' utilities?
- Is it a voluntary strategy or based on regulation?
- Are financial incentives provided or not?
- Is the investment influenced, e.g. subsidized or the kWh generated by a PV system?
- Who is addressed by the strategy? PV generators? PV electricity users? Or a specific target group? E.g. architects, teachers, schools, building construction companies?

In the following it is described which fundamental types of strategies exist. Table 1 provides an overview.

2.2.1. Governmental target programmes

In this case the strategy is based on a government decision on the desired level of generation or market penetration of electricity from different RES. The price is in principle set through competition between generators. Financial incentives may support this type of a strategy but they are not compulsory.

2.2.1.1. National targets Non-mandatory capacity targets or number of systems installed.

2.2.1.2. Mandatory targets Renewable portfolio standards/quotas, tradable green certificates (TGC), renewable energy or CO_2 based certificates.

2.2.1.3. Financial incentives Regulated financial incentives: generators of electricity from RES receive financial support in terms of a subsidy per kWp capacity installed or a payment per kWh produced and sold.

- Investment focused: rebates, income tax incentives, soft loans.
- Generation based: This type of strategy is typically based on regulated rates. Examples are: Net metering, enhanced feed-in tariffs, rate-based incentives (RBIs,

Table 1
Categories of strategies: voluntary versus regulatory, capacity targets versus financial incentives, investment focussed versus generation based

		Regulatory	Voluntary
Target programmes		RPS Bidding/tendering Quotas, TGCs	National installment or capacity targets
Financial incentives	Generation based	Feed-in tariffs RBIs Net metering	Green Power marketing Green tariffs Solar stock exchange
	Investment focused	Rebates Soft loans Tax incentives	Contracting Shareholder programme Contribution Bidding
Other		–	NGO marketing Selling green buildings Retailer programme Financing Public building programme

= 'Kostendeckende Vergütung' for PV in Germany, Austria and Switzerland); environmental pricing.

Voluntary approaches with financial incentives: This type of strategy is mainly based on the WTP (willingness to pay) of different categories of customers. The strategy is usually launched by an electric utility. The financial incentive is provided by a PV electricity user with a corresponding WTP. This type of strategy can be split into two categories:

- Investment focused: shareholder programmes, contribution programmes, voluntary bidding/tendering.
- Generation based: green tariffs, w/ or w/o labelling, 'Solarastrombörse', Green power marketing (in liberalised electricity markets).

Indirect financial incentives: PV electricity can also be promoted by means of indirect strategies, as e.g. CO_2 taxes, penalties for not meeting mandatory targets or removal of subsidies for fossil fuel and nuclear generation.

Other strategies: other programmes encompass marketing programmes by NGO's or by commercial companies (e.g. selling Green buildings), retailer programmes (e.g. franchising, guaranteed yield), programmes for public buildings (schools, townhalls, churches), and voluntary financing programmes by private companies (general information campaigns and education programmes, programmes for specific target groups e.g. architects?).

3. Governmental target programmes

In some countries programmes have been introduced or are intended to be launched which focus on a certain target for a market share or installed capacity of PV or renewables in general.

In principle, both, voluntary and mandatory strategies are possible.

3.1. Voluntary capacity targets or number of installations targets

Such programmes has been introduced in Switzerland (ENERGIE, 2000), The Netherlands (NOVEM programme), the USA (Presidents' million roof programme) and by the EC (1 000 000 roofs programme).

3.1.1. The 1 000 000 roofs programme of the European Commission

Generating electricity from renewable energy sources (RESs) currently has a high priority in the energy policy strategies of the European Commission. Since 1979 the EC supports the dissemination of PV by means of various programmes (e.g. THERMIE and ALTENER).

A milestone for the political promotion of PV in Europe was the EC's 'White Paper on Renewable Sources of Energy' (EC 1997). In 1999 the *Campaign for take-*

off (CTO) was launched. A comprehensive range of measures is proposed to overcome barriers to the development of renewables and to redress imbalances. Within the CTO it is intended to promote 1 000 000 PV systems until 2003. It is aimed for installing 500 000 PV systems on roofs and facades within the domestic European market and an export initiative for another 500 000 PV village systems to start the decentralised electrification in developing countries. Furthermore, the proposal (common position) for a directive of the European Parliament and the council On the promotion of electricity from RESs in the internal electricity market (Council of the European Union, 2001) set the challenging goal to substantially increase the share of renewables in the electricity mix of EU countries from 13.9% in 1997 to 22% in 2010. This should also contribute to meeting the objective of the CTO and to promote PV.

3.1.2. The Swiss 'ENERGIE 2000' programme

In Switzerland in the early 1990s the so-called 'ENERGIE 2000' programme — has been launched by governmental institutions. Within this programme the promotion of various energy conserving and solar energy converting technologies is planned and specific goals of market penetration should be reached by the year 2000. The 'ENERGIE 2000' programme is obviously over. The follow-up programme started in 2000 and is called 'EnergieSchweiz'.

For PV a capacity of 50 MWp was planned. At the end of 1999 about 14 MWp were installed. Until 1999 the PV systems were subsidised by around 1700 EURO/kWp (3000 SFr/kWp). Currently (2002) no government rebates are available anymore. This has been transferred to the individual Cantons and is being regulated differently. In some Cantons subsidies are available, in others none.

The major current strategy initiated under the 'ENERGIE 2000' programme is the campaign 'Solarstrom vom E-Werk'' It has been started in 1996 and since then attracted 30 000 customers until the end of 2001. More than 100 utilities are currently (2001) offering 'Solarstrom' compared to 6 in 1996. The installed capacity grew from 3.4 MWp in 1999 to about 6 MWp at the end of 2001, see Fig. 3. Source: Frauenfelder [19], and Frauenfelder (personal information).

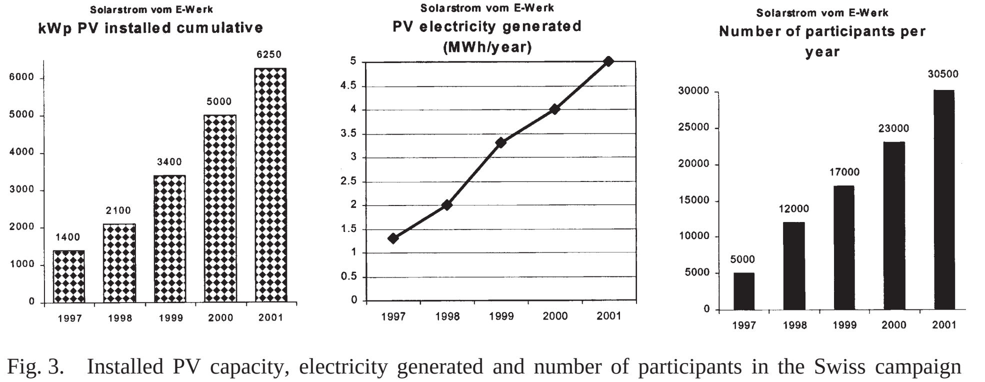


Fig. 3. Installed PV capacity, electricity generated and number of participants in the Swiss campaign 'Solarstrom vom E-Werk' 1997–2001.

3.1.3. The Dutch ‘NOZ-PV’ programme

In 1994 in The Netherlands various organisations under the leadership of the ministry for energy and environment (represented by NOVEM) launched a cooperation for a broader market dissemination of decentralised PV systems, the so-called NOZ-pv programme. Due to the Dutch ‘PV introduction plan’ (NOVEM 1997) it was planned to install 7.7 MWp of PV capacity till the year 2000 respectively 500 MW till 2010 (see Schoen 2000). The first target of 7.7 MWp was surpassed with 9.2 MWp installed already by the end of 1999 and 12.5 MW installed by the end of 2000.

The new PV covenant is anticipated to aim at a target of 300 MW by 2010 and 1400 MW by 2020, see Fig. 4. Moreover it is intended to reduce the investment costs to 2.75 NLG/kW in 2010 (source: [6]). Within this programme to some extent strongly reduced rebates are foreseen. Remark: in 2002 and 2003 the Dutch policy changed several times.

3.1.4. German target programmes

In Germany the first national target programme took place from 1991 till 1995, the ‘German 1000 roofs programme’. In 1999 another PV target programme has been launched, the ‘100 000 roofs programme’. For further details of these programmes see sections 8.1.1 and 8.2.1.

3.1.5. Japanese targets

Within the New Sunshine project in 1996 the Japanese government announced targets of 400 MWp by 2000 and 4600 MWp by 2010. For details of the residential rebate programme see section 7.1.2.

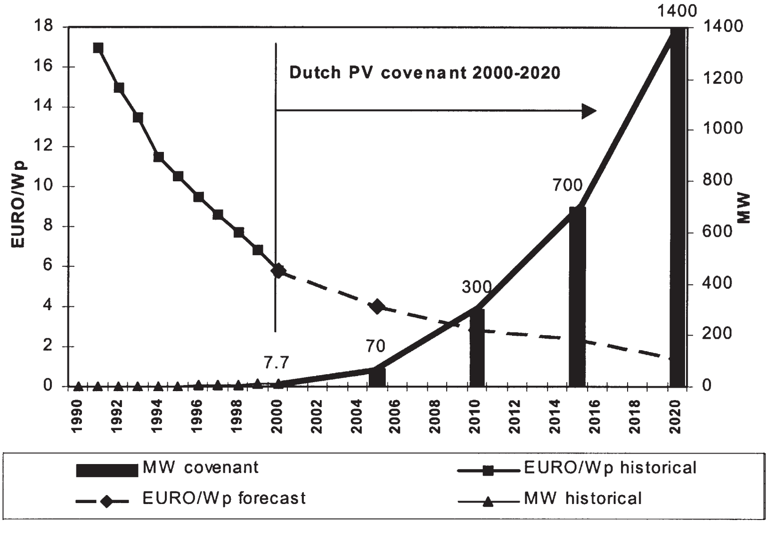


Fig. 4. Installed PV capacity and cost development in The Netherlands: Historical numbers and planned development due to the Dutch PV covenant programme 2000–2020.

3.1.6. USA: The President's million solar roofs initiative

In 1997 the former American president Clinton announced the so-called 'million solar roofs initiative'. Within this programme a million roofs in the USA should be equipped with a PV system and/or a solar thermal system for water heating, pool heating, or space heating. With respect to PV the *Team-Up initiative* with its 'friendly PV programmes' is of special relevance. In this programme eight utilities have joined and market green electricity differently. Moreover, tax credits up to US$ 2000 are possible for individual systems.

3.1.7. Italy's 'Fonti rinnovabili' programme

In Italy since 1998 a 10 000 roofs programme was announced. The programme was aiming at installing 50 MWp of small PV systems over 5 years.

Now it is obvious that this programme will never be put into practice. Instead in 2001 the 'Programmi Fonti rinnovabili' 2001 was announced with a special sub-programme on PV called 'Tetti fotovoltaici'. This programme intends to install 7 MW of PV.

3.1.8. Spanish targets

The Spanish government has already conducted a renewable energy programme from 1991 to 2000. Within this programme 5 MW of PV has been installed. In order to continue with the dissemination of RES a new plan for the period of 2000–2010 has been approved. Due to the 'Plan de Fomento de las Energias Renovables' launched in 1999 a target of 135 MW of PV capacity is set for 2010. Most important is the Royal Decree which requires utilities to pay an economic incentive for PV electricity fed into the grid, see section 8.1.

3.1.9. Finnish targets

The National Climate Change Programme intends to install 40 MW by 2010. It will be subsidized with 35 Mill. Euro.

3.2. Mandatory targets

In some countries mandatory targets — e.g. quotas or renewable portfolio standards (RPSs) — have been introduced. Yet, so far it is not possible to provide lessons learned for this programmes. In the following the most important ones which at least include PV are shortly described.

3.2.1. RPSs in the USA

The basic idea of the so called RPSs is to ensure that a certain minimum percentage of electricity is generated by renewables but to encourage maximum efficiency by allowing the market to determine the most cost-effective solution for each electricity retailer.

Under a RPS, all retail electricity suppliers are required to obtain a certain minimum percentage of their electricity from RES, in the form of 'renewable energy credits' (RECs). Electricity retailers can obtain RECs in three ways. They can own

their own renewable energy generation, and each kWh generated by these plants would represent one REC. They can purchase renewable energy from a separate renewable energy generator, hence obtaining one REC for each kWh of renewable electricity they purchase. Or, they can purchase RECs, without purchasing the actual power, from a broker who facilitates trades between various buyers and sellers. RECs are, therefore, certificates of proof that one kWh of electricity has been generated by renewables, and these RECs can be traded independently of the power itself.

RPS have been implemented in some federal states of the US (e.g. Arizona, Connecticut, Iowa, Maine, Massachusetts and Nevada). Table 2 list the programmes which include PV.

3.2.2. Australia's 2% additional RES target till 2010

The Australian government has recently required electricity retailers and large purchasers to meet a target of 9500 GWh (approximately an additional 2%) of their electricity from RES by 2010. The measure is implemented by RECs trading, as described, however, each REC is worth 1 MWh. A penalty of AUD 40 per MWh will apply for non-compliance. Yet, there is no special commitment to PV.

3.2.3. Austria's 4% target programme till 2007

In July 2000, the Austrian Parliament adopted a new Electricity Act, reflecting the proposal for a directive of the European Parliament and the council On the promotion of electricity from RESs in the internal electricity market (Council of the European Union, 2001). The Act requires that by 2007 'new renewables' account for 4% of the electricity sold to the final users. The provincial governors have fixed minimum feed-in tariffs for different technologies of this green electricity. This will bring about a change in the existing regulations. Extra costs incurred by the distribution companies will be compensated for by an additional tariff. Furthermore, the Act provides for the possibility of selling green electricity directly to customers, i.e. enterprises producing electricity from RES may conclude delivery contracts not only with eligible customers, but with any customer.

3.2.4. Upper Austria's bidding programme

The first governmental bidding programme for decentralised grid-connected PV so far has been launched In Upper Austria in 2000. It sets targets and financial incentives for different types of RES-E. There is a special obligation for PV of 220 kW/year. To meet this target a budget of 1 Mio EURO per year is available.

In the first year (2000) this programme has been successful. Further information is not yet available. (source: personal information Heinrich Wilk).

3.3. Public purpose programmes in the USA

In the light of the looming restructuring of the ESI, various states of the USA intend to implement different types of public purpose programmes. These programmes are based on charges on transmission fees (system benefit charges). The most important ones are listed in Table 3. Yet, so far it is not possible to assess the

Table 2
Green tariff schemes

Utility (country)	Startyear	Product/Label (PV share)	Premium/price ()	Number of parti-cipants (year)	Partici-pation rate	PV capacity installed (kW)	PV electricity generated (MWh/year)	kWh per participant per year	Status
RWE (D)	6/1996-	Umwelttarif (26% PV)	10.22 ct/ kWh (Mix)	15800 (1998) 12500 (2000)	0.5%	1050	800		ON
ENBW (D)	2/1997	Umwelttarif grün (1 % PV)	4.1 ct/ kWh(Mix)	2070(2000)	0312	?	?		ON
	2/1997	Umwelttarif solar (100% PV)	81.8 ct/ kWh	230(2000)	0.013	62	59		ON
Elektra Basel Liestal (CH)	1992	Solar-strom für alle!’	1.40 (1998) 1.30 (2000) sFr/kWh	333(2000)	N.A.	104	84	252	ON
Elektra Birseck München-stein (CH)	1994	EBM-Solar’	1.40 sFr/kWh	440(2000)	N.A.	71	85	180	ON
Göteborg Energi(S)	1997		1 öre/ kWh	2400(2000)	N.A.	40	28		ON
NUON (NL)	1996	Natuurstroom (0.5% PV)	0.09 NLG/kWh	52000(2000)	N.A.	1000	702	N.A.	ON
Energy Australia	1997	Pure Energy’/GreenPower	13.7 A$c /kWh (40% premium for 100% greenpower)	15500(2000)	N.A.	600	877	56	ON
Arizona Public Service (USA)	1997	Solar Partner’	17.6 US$ cent/kWh	1600(2000)	N.A.	500			ON
Salt River project (USA)	1998–2000	N.A.	20 US$ cent/kWh	N.A.	N.A.	200			OFF

Source: own investigations, Sweden: Mats Andersson.

Table 3
Public purpose programmes/system benefit charges in the USA

State	Description
California	US$ 540 million per year over four years where from US$ 54 are dedicated to Emerging Renewables
Illinois	5.0 c/month surcharge on residential customers for 10 years
Massachusetts	A yearly increasing charge starting at 0.075 c/kWh from all customers will provide US$ 150 over the period 1998–2002
Montana	2.4% of total revenues
Rhode Island	0.23 c/kWh for next five years, all customers

effect of this programme type on the dissemination of PV. With respect to California see also section 4.1.5.

4. Capacity-based governmental financial incentives (rebates programmes, soft loans, tax incentives)

This section describes the most important governmental financial incentives programmes worldwide, focusing on the capacity of PV installed and introduced so far. This category emcompasses mainly governmental rebates, governmental financing programmes (e.g. soft loans) and tax incentives on investment.

4.1. Rebate programmes

4.1.1. The German 1000 roofs program

The first comprehensive international dissemination programme was the ‘1000 roofs programme’ launched in Germany in 1989. This programme was completed in 1994. Some 2250 German roofs were equipped with PV systems of an average size of 2.6 kWp and a total capacity of about 6.15 MWp. Average system costs were 15 000 USD/kWp, average subsidies 70% of the investment costs. During this dissemination programme and also in the aftermath comprehensive investigations on technical and sociological aspects of this programme took place. The major results of this programme were that PV systems reached a certain standard of technical reliability, that PV system costs dropped, and that the acceptance of this technology increased considerably. Moreover, experiences gained in this programme were also used for similar activities in Austria and Japan. The major references for the German 1000 roofs programme are Genennig and Hoffmann [7], and ISE [8].

4.1.2. The Austrian 200 kW rooftop programme

In 1991 the Austrian Ministry for Economic Affairs launched a promotion programme for small decentralized PV systems, the 200 kWp PV-rooftop programme. It took place between 1992 and 1994. Within this programme about 100 small residential grid-connected systems were subsidized by utilities and governmental auth-

orities. The total installed capacity was 203.6 kWp. The average capacity was 2.28 kWp. Average system costs were about US$ 16 000. About 58% of the investment costs were subsidized by authorities and electric utilities. For further details see e.g. Haas et al. (1997), and Wilk [9].

The major targets of the 200 kWp rooftop programme were:

1. collecting comprehensive operation data as a basis for further R&D activities on various components of PV systems;
2. testing and assessing the long-term performance of small decentralized PV systems;
3. investigating the maintenance efforts for small PV systems;
4. optimizing the system design of grid-connected systems; and
5. acceleration of the market penetration of PV.

4.1.3. The Japanese 'residential PV system dissemination programme'

The largest dissemination programme so far worldwide was launched in Japan in 1994. In the following years the number of small grid-connected systems (SGCSs) skyrocketed, see Fig. 5.

This programme was and is to some extent combined with low-interest consumer loans and comprehensive education and awareness activities for PV. The programme makes blocks of funds available to PV system retailers in a competitive bid programme.

This programme is still ongoing and expected to expire in 2002.

In 1997 the 'New Energy Promotion Law' was introduced as part of the New Sunshine project. It ensured subsidies for PV and it announced targets of 400 MWp by 2000 and 4800 MWp by 2010 [10].

While in 1994 'only' about 540 systems has been installed up to the end of

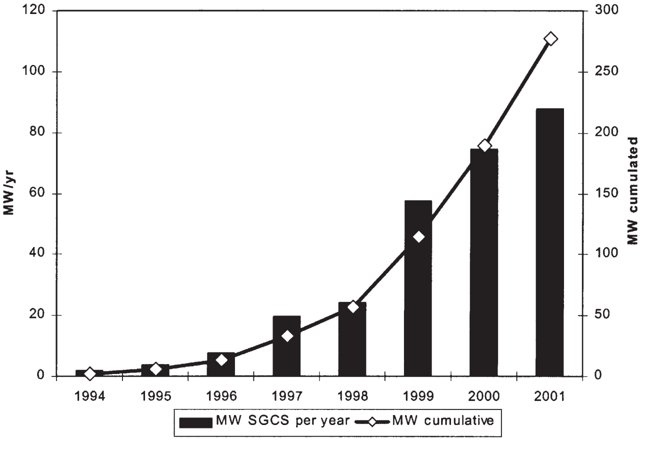


Fig. 5. Japanese residential PV promotion programme: development of installed capacity and average capacity.

FY2001 about 75 000 SGCSs with an average capacity of about 3.6 kWp has been installed. In FY 2000 and 2001 alone >20 000 systems were installed. It is expected that this number will increase to about 29000 in FY 2002 [11]. This led to around 88 MW installed in FY2001 and to a cumulated installed capacity of 270 MW in Japan by the end of FY2000. The most important details are summarized in Table 4. To put these figures in perspective: worldwide PV production in 2001 was about 400 MW.

In the Japanese programme rebates decreased continuously over time. From 1994 to 1996 the subsidies were 50% of the total investment costs. They were reduced from 50% of the total investment costs in 1994 to about 30% in 1999. In 1998 about 8000 systems were subsidized. The upper limit for rebates has been reduced from 900 000 JPY in FY1994 to 500 000 JPY in FY1996 and 329 000 JPY in FY1999, see Fig. 5. For the FY 2000 it was decided to switch to a fixed amount of subsidies per kW of 270 000 JPY /kW in the first half of the year and to 180 000 JPY/kW in the second half.

A major question is whether the Japanese programme has brought down the PV price substantially. Currently, it appears that is has. Yet, from 1996 to 1999 the decline has been very moderate. The average price of a residential PV system decreased from 939 000 JPY/kW in FY1999 to 774 000 JPY /kW in FY2001. Fig. 6 depicts the development of investment costs and subsidies in Japanese Yen over the time period of the promotion programme.

A result of these efforts is that Japan is now the world leader in the development of grid-connected systems. This success is the direct result of a conscious policy to promote PV technology, both for reasons of national energy security (Japan imports most of its fuels) and for reasons of economic development (Japan aims to dominate PV manufacturing to the same extent as it dominates the production of electronic equipment).

Major references: Ikki [11].

4.1.4. The REN programme in NRW in Germany

The first and the longest PV rebate programme that has been launched worldwide was the REN programme in North-Rhine–Westfalia (NRW) in Germany. Over the period 1988 until 2001 an overall capacity of about 35 MW of PV has been installed. These installations has been funded with about 150 million Deutsche Mark (about 75 million EUR). As can be seen from Fig. 7 the number of systems has been increasing tremendously in the last 3 years. In the year 2001 about 10 MWp has been installed.

In February 2001 the new REN programme, which can be combined with the 100 000 roofs programme started. It offers 1500 EUR (3000 DEM) per kW to private households for building-integrated PV systems and 750 EUR (1500 DEM) for systems>5 kWp without building integration. Moreover, there is a special rebate for ‘multipliers’ like schools of 1000 EUR (2000 DEM)/kWp.

Table 4
Number of installations/applications and capacity installed in the Japanese Residential PV dissemination programme (source: Ikki 2002)

		FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001[a]
Number of installations	Total per year	539	1065	1986	5654	6352	15879	20877	22600[a]
	Cumulative	539	1604	3590	9244	15596	31475	52352	75000[a]
Generation capacity	MW/year	1.9	3.9	7.5	19.5	24.1	57.7	74.4	88.0[a]
	Cumulative	1.9	5.8	13.3	32.8	56.9	114.6	189.0	277[a]
Budget	M JPY/year	2.0	3.3	4.0	11.1	14.7	16.0	14.5	23.5[a]

[a] The numbers for FY 2001 are estimated by means of multiplying the number of applications in 2001 (29 400 systems with an overall capacity of 114.7 MW due to Ikki, 'PV Activities in Japan', May 2002) with the achievement percentage of 2000 (77%).

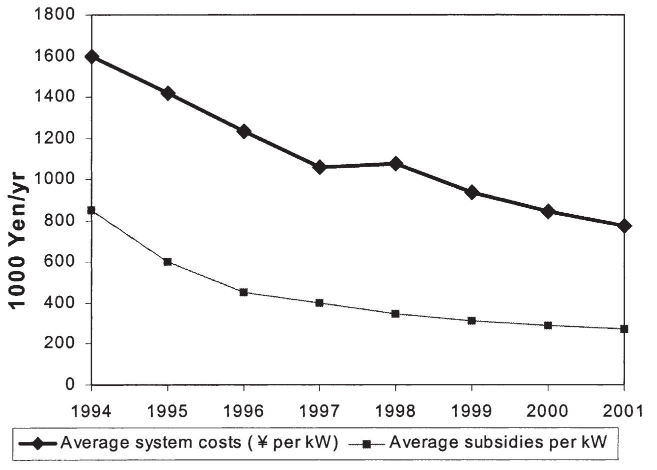


Fig. 6. Japanese residential PV promotion programme: development of investment costs and rebates 1994–2001.

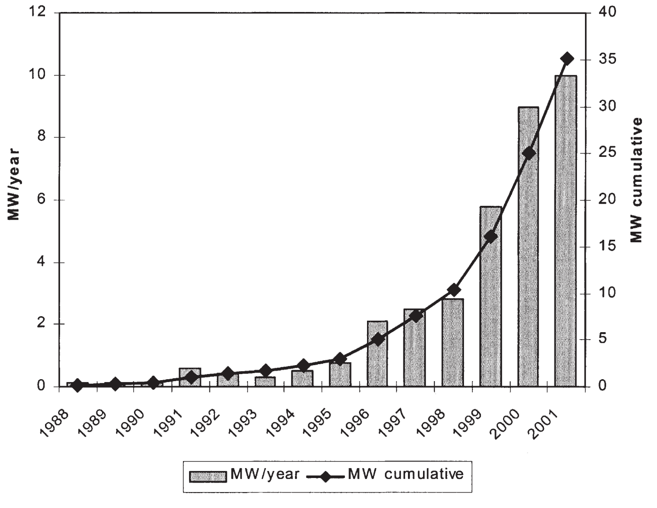


Fig. 7. Development of installed capacities in the REN programme of NRW in Germany.

4.1.5. California's emerging renewables buydown programme (CERBP)

In September 1996, the California legislature passed Assembly Bill No. 1890 (AB 1890). This law requires Californiás three largest investor-owned utilities to collect US$ 540 million from their customers over 4 years to support electricity generation from renewable technologies. Ten percent or 54 million was approved for a multi-year rebate programme for selected emerging technologies, including PV, small wind (10 kW or less, fuel cells using renewable fuels and solar thermal electric generation. Additional funding has since brought the total to US$92 million. The programme began accepting applications on 20 March 1998.

The programme guidelines for CERBP required all retailers receiving a buydown payment to provide a ‘full 5-year warranty’ to the purchaser against breakdown or degradation of output.

Five tiers with US$10.5 million in each of the first four tiers and US$12.0 million in the fifth were planned. It set the maximum buydown per Watt of system output at US$3/W in the first tier, declining US$0.50 per tier to US$1/W in the final tier. The tiers are not tied to a calendar year or any other specific time frame. Instead, each block of funds would be made available until exhausted.

Yet until 2000 the number of applications was rather disappointing. By the end of 2000 only about 1 MW of PV have been installed due to the CERBP in California. In 2001, when the combination of high natural gas prices and a flawed deregulation structure sent electricity prices soaring, the tiered rebate was abandoned and rebates were increased to US$ 4.50/W for all sizes of systems (see Fig. 7). Along with the high electricity prices this led to a sharp increase in the number of applications in 2001 see Fig. 7 (Source: [17]). While from 1998 to 2002 the number of applications was around 30 per month in 2001 it increased to around 300 per month. Yet, as Bolinger and Wiser [12] argue the surge in activity in 2001 started already in the first quarter while the rebate was raised only in the second quarter.

Yet, as Fig. 8 depicts since the peak in the third quarter of 2001 the number of applications declines continuously. By June 2002 around 24 MW of PV have been installed or reserved under California’s buy-down programme.

Moreover, anticipated cost reductions have not materialised. An investigation on the cost development from 1998 to 2000 found virtually no cost reductions [12]. Since then the costs slightly decreased, see Fig. 7.

The proposed programme from 2002 to 2007, which would provide about US$ 25 million per year in rebates, will require legislative approval. As of October 2001

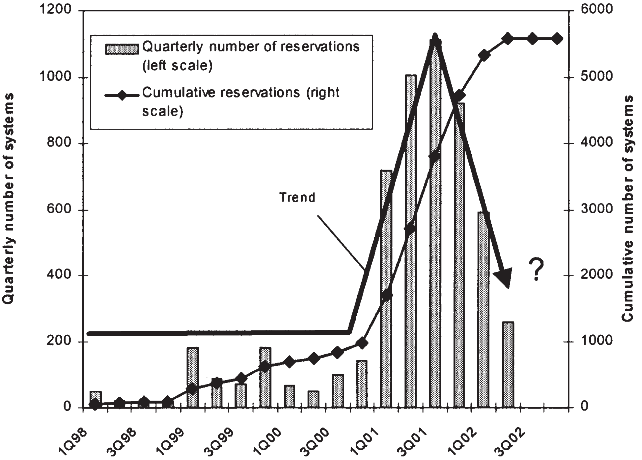


Fig. 8. Development of applications in the California energing renewable buydown programme from 1998 to 2002 (source: [12, 17]).

almost US$ 65 million of funding had been encumbered or paid-out for 17 MW, primarily for solar (Fig. 9).

4.1.6. Spain: PAEE

The PAEE ('Plan de Ahorro y Eficiencia Energética') is run by different regions in Spain. It subsidizes PV installations to a maximum of 4.1 EUR/Wp (600 PTA/Wp) for on-grid and 8.2 EUR/Wp (1200 PTA/Wp) for off-grid systems. The PAEE started in 1991 and ended in 2000. The public resources to promote PV was 2950 millions of pesetas what would imply the 50% of the associated investments. Currently it is estimated that due to the PAEE about 7000 MWp of PV (including stand-alone systems, grid-connected systems and demonstration projects) has been installed by the end of 2000.

4.1.7. The Australian rebate programmes

4.1.7.1. The SEDA programme The Sustainable Energy Development Authority (SEDA) launched its BIPV programme in August 1998 in the state of NSW. Since then it has approved over 200 applications with an average capacity of 1.3 kWp. Over AUS$ 500 000 in cash rebates were provided for BIPV systems.

In the first year until the end of 1999 more than two thirds of the applications were in the residential sector. 60% of all systems were grid-connected systems. When in June 1999 the Commonwealth government announced its new PV rebate programme the number of applications dropped considerably. The offer of AUS$ 5500 AUS per kWp was enough to persuade people to postpone their purchases until the new year (Williamson 2000).

Currently, in 2001 SEDA, offers a rebate of AUS$ 2400 per kWp for non-residential buildings (small business and commercial buildings) and a rebate of AUS$ 4800

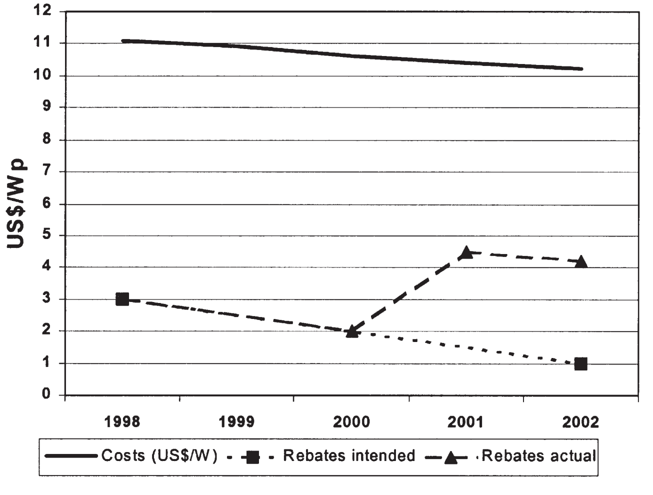


Fig. 9. System cost and rebates from 1998 to 2002 in the California energing renewable buydown programme.

per kWp for installations on community use buildings such as schools, town halls and other public buildings.

4.1.7.2. The governmental PV rebate programme (PVRP) In January 2000 the Australian government launched the PVRP with a budget of AUS$ 31 million. The programme is operated by the Australian Greenhouse Office (AGO). In the beginning a rebate of AUS$ 5500 per kW was provided with a cap of AUS$ 8250 or 1.5 kWp. This rebate was offered for small rooftop and building-integrated PV systems until September 2000. In October 2000 the rebate was reduced to AUS$ 5000 per kW and capped at AUS$ 7500 for new systems and AUS$ 2500 per kW for upgrades on existing systems with a 2500 AUS$ cap. The reason was that the budget planned for four years was used up nearly twice as fast as expected and planned (Hirshman 2001). By the end of December 2000 about 2600 applications has been pre-approved, averaging at about 1 kW per system.

Another important reason for the revision of the rebate was that the original rebate of AUS$ 5500 per kW was only on solar panels. Hence, investors who had already put in PV installations were taking advantage of the PV rebate to boost the power of their systems while first-time purchasers still needed to buy equipment such as inverters and batteries, which at that time were not covered by the rebate.

Fig. 10 depicts the development of the PVPR in the first 27 months. The first spike in approvals in June 2000 was caused by the introduction of 10% GST (VAT) on 1 July 2000. The second spike in September was caused by the announcement of the reduction of the rebate in October. Of interest is also that more than 70% of all systems installed are stand-alone systems. By the end of March 2002 almost 3000 stand-alone systems were promoted vs 970 grid-connected systems.

Finally, it has to be stated that industry representatives are unhappy that the PVPR has been so heavily weighted towards off-grid installations. They argue that the PVPR has provided a windfall profit for the off-grid installations at the expense of the far more difficult market of grid-connected PV where it must compete against electricity prices of around AUS$ 0.12 per kWh.

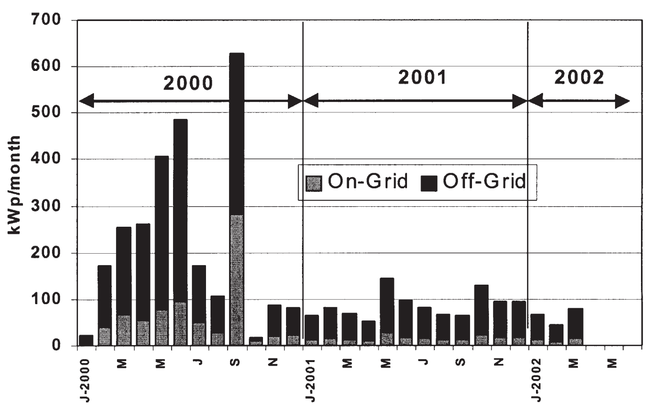


Fig. 10. kWp approved in the first years of the Australian PVRP (source: AGO homepage).

4.1.8. The Dutch 'PV GO!' tendering programme

In The Netherlands in 2000 NOVEM launched the PV-GO! rebate programme (ECOFYS, 2000). PV-GO! is a tender programme for specific grid-connected PV applications with sufficient marketing potential. PV-GO! contributes up to 25% of the system costs. Offers are ranked according to the required subsidy per Watt-Peak. The total budget in 2000 was 7.2 MEUR intended to support 6 MW additional PV capacity. In the first round in Spring 2000, proposals for a total of 1.7 MWp were submitted (total requested subsidy 2.4 M EUR). Results of the second round (November 2000) are not yet known. To date, approximately 900 kWp of systems as been realized under the pv-GO! tender.

In 2001, pv-GO! was replaced by a new mechanism, providing individual PV system owners with a rebate of 3.4 EUR/Wp (the energy premium scheme, EPR). This is a traditional rebate programme, in which individual system owners have to apply for subsidies through their utilities. Funds for the rebate programme come from the energy tax.

The quick move from Novem R&D programme to pv-GO! to EPR has given industry little security to build up capacity and marketing schemes. Market growth seems to have slowed down.

4.1.9. The Italian rebate programme

In March 2001 in Italy a rebate programme was lauded which subsidizes 75% of the investment costs (Maximum investment costs: 8 EUR/Wp). For a more comprehensive description see: PVPS Annual report 2001. So far no lessons learned in detail are available.

4.2. Financing programmes

4.2.1. The German 100 000 roofs programme

Since 1999 a new financial approach is being pursued in Germany with the 100 000 roofs programme. Within this programme very attractive credits (soft loans) are provided to the public. Initially the interest rate was 0% (in 1999) for 10 years payback time. The loan is to be repaid in eight instalments from years 3 to 10, and the last instalment in year 10 is cancelled if the system is still operating. The response to this programme in the first year (1999) was disappointing. Only about 3000 new projects (about 9 MWp) were approved. This was only half of the planned capacity of 18 MWp. In March 2000 the German Law for the priority of renewable energy came into force with the accompanied introduction of a substantial feed-in tariff of 99 Pfennig/kWh (0.5 EUR/kWh) for PV in March 2000. This was a major reason for the boost in April 2000 — see Fig. 7. Then the programme was stopped for almost half a year and the initial plan was revised, see Fig. 7. The interest rate was raised from 0% in 1999 to 1.8% in June 2000. The target for 2000 was raised to 50 MW/year increasing to 95 MW/year in the year 2003 when the programme is expected to be terminated. But the second target in the year 2000 was also missed see Fig. 7. In 2000 41.7 MW were installed instead of the target of 50 MW. For 2001 65 MW were planned in addition to the 9 MW missing from the first two years.

This target was met with a total capacity of applications of 126 MW cumulated. In the first half of 2002 the growth was beyond the planned target see Fig. 11.

It can be seen that, a lot of 'Stop and Go' took place since the start of this programme. It is not yet possible to determine which instrument had more influence on increasing the rate of installations: the loan or the feed-in tariff.

4.2.2. The Dutch Green Funds

In The Netherlands, 'Green Funds' money is made available at a lower interest rate (about 1%) for so-called 'green projects'. PV projects are seen as 'green projects'. Green Funds are under the supervision of the Dutch Central Bank. However as reported by ECOFYS (2000) few PV systems have actually been supported. Most likely this has only occurred through green mortgages which are a part of the green funds programme (ECOFYS 2000). No detailed information on the dissemination effect of 'green funds' for PV systems is available.

4.2.3. Tax incentives on investments

In various countries it is possible to deduct the investment in PV systems (or in renewable energy technologies in general) completely or partly from income tax.

Several different options have been used to promote the generation of electricity from RES with fiscal instruments:

- lower VAT-rate applied for RES-E systems; and
- dividends from RES-Investment made exempt from income taxes.

Both options have similar impact, acting as moderate investment subsidies for new installations.

In Table 5 an overview of existing investment-based tax incentives and how they are implemented in different countries is given. Further details for PV systems in the US are described by Eiffert et al. (2001).

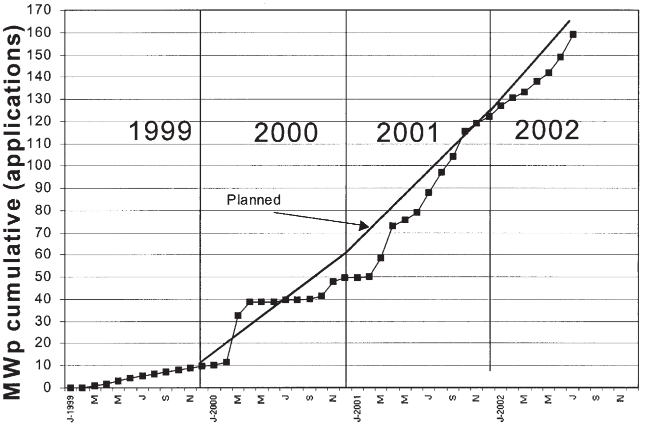


Fig. 11. The German 100 000 roofs programme: cumulative applications of the first four years.

Table 5
Tax incentives on investments in PV in various countries

Country	Investment-based tax incentives
Austria	Private investors get tax credits for investments in renewable energies (personal income tax)
Belgium	13.5–14% of RES investments deductible from company profits, regressive depreciation of investments
Greece	Up to 75% of RES investments can be deducted
Ireland	Tax relief for certain RES investments
Italy	Up to 36% tax reductions of the investment costs of a PV system are available and a VAT reduction from 20% to 10%.
Japan	The taxable amount of fixed property is reduced to 5/6 for 3 years if a PV system is installed
The Netherlands	*VAMIL scheme:* RES-investors (specific renewable technologies) are allowed to offset depreciation of their investments against taxable profits*EIA scheme:* RES-investors (same technologies as VAMIL) are eligible for an additional tax deduction against their profits (from 52.5% to 40% depending on sum of the investment)
UK	Reduction of VAT (5% rather than 17.5%) on domestic PV and wind generating capacity cost
US/New York	25% of RES-investments deductible from private income tax a tax deduction of 2000 USD/kWp is possible for individual PV systems within the *Team-Up initiative* with its ‘friendly PV programmes’

So far no clear dissemination effect for PV has been identified due to this promotion instrument.

5. Regulated rates

In recent years in various countries other types of financing models have been introduced which are based on regulated rates. In the following the most important models are described briefly.

5.1. Net metering

Since the early 1980s especially in the US the financing model 'Net metering' has gained attention for PV (and other renewable and CHP electricity). Within this approach the net excess generated electricity (NEG) is refunded by the utility at by and large the same price as the retail price of electricity.

In Japan net-metering has been available since 1992. In Denmark net-metering was established mid-1998 for a pilot period of 4 years. In most states of Australia net-metering is applied for residential customers by some utilities since the mid-1990s.

So far no lessons learned from these countries are available.

5.2. Enhanced feed-in tariffs

With enhanced feed-in tariffs electricity from renewables is purchased at a higher price than the electricity retail price. These tariffs have attracted attention since the late 1980s. Currently the highest general 'feed-in'— prices in Europe are in force in Spain, Germany and Austria, see Figs. 12 and 13.

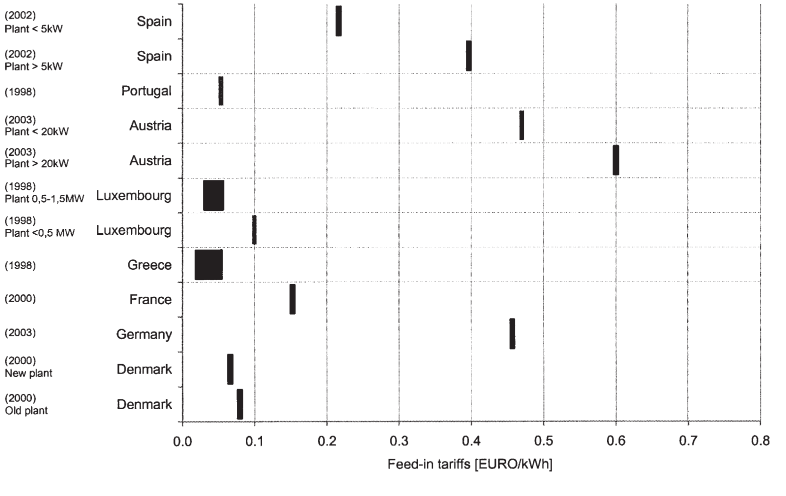


Fig. 12. Feed-in tariffs for PV in various countries in 2002.

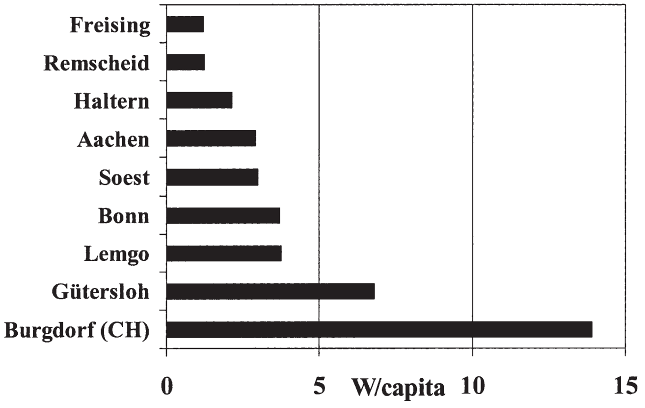


Fig. 13. Installed PV-capacity per capita in German cities with RBIs.

5.3. *RBIs*

In the early 1990s, at almost the same time in Burgdorf in Switzerland and in Aachen in Germany, the idea of 'full cost rates' (Kostendeckende Vergütung) was launched. This means that the public utility has to buy back PV electricity at (almost) the full production costs. The Aachen Model was first proposed in 1992, and was implemented 1 September 1994. Individuals or businesses who invest in photovoltaics are paid for every kilowatt hour of solar energy the PV system feeds back to the grid. In the early phase of RBI PV investors in Germany received two Deutsche Mark per kilowatt hour (1≈ US$/kWh or 1 €/kWh). In the course of the time this rate has been reduced. The rate is guaranteed for a time frame of between 10 and 20 years. Hence, the generators can fully recover their cost of purchasing and installing the PV system.

Cost recovery is funded through a surcharge on electric utility bills paid by the public 'rate-base' of the utility. Usually a programme ceiling limits the number of installations which obtain the RBI. Examples are a limited surcharge on the electric bill of all customers or a limit with respect to the overall promoted capacity. The limit of this surcharge is still in discussion and varies from state to state between 0.6% (Bavaria) and 1%. Mostly 1% is accepted by the ministers of economy.

This idea has gained attention mainly in cities where municipal utilities are responsible for power supply and where local politicians have the power to put these full cost rates into practice. The programme has been implemented in cities where the public and the politicians support the idea of a utility bill surcharge to encourage the installation of photovoltaics. They have gained special attention mainly in Germany and in some cities in Switzerland and Austria. They vary currently between about US$ 0.7 and US$ 1.0. Fig. 8 shows the installed PV capacity per capita in those cities where RBIs were most successful.

Note that in some cities the limit of the cap of price increases has already been reached.

6. Voluntary investment-focused financial incentive programmes

Under this type of programme utilities, NGOs or other companies do usually provide financial incentives for a PV generator. The financial incentive is tied to generation capacity and is paid e.g. per kW. The financial incentives may be collected from private individuals or a utilities' electricity consumers. Of course, it is also possible, that the utility itself is the generator.

6.1. Contracting

Under 'Contracting' an organisation e.g. a utility pre-finances the investment for the customer and the customer pays back a certain amount per month or per year. Finally, the customer owns the PV system.

6.1.1. SMUD's 'PV pioneer I programme

The first and so far most popular contracting programme worldwide for PV was launched in 1993 by SMUD in California. It was the so-called 'PV pioneer I programme' homeowner's property? Under this programme the system was purchased, installed, owned and operated by SMUD, see Osborn [18]. It feeds its power directly into the SMUD electric grid. SMUD residential customers volunteer to share in this effort through a form of 'green pricing' and by providing the roof area to place the SMUD 'PV power plants', each about 4 kWp. The PV Pioneer I customer pays a US$4 per month 'green' premium in addition to their normal utility bill to participate.

This programme is aimed at developing the experience needed to successfully integrate PV as distributed generation into the utility system, developing long-term market and business strategies and stimulating the collaborative processes needed to accelerate the cost-reductions necessary for PV to be cost-competitive in these applications by about the year 2003.

This effort has resulted in about 8 MWp of PV systems installed in Sacramento, distributed over some 700 installations by the end of 2000.

SMUD gains experience in the installation, operation, maintenance, pricing strategies and other aspects of residential PV systems and obtain low-cost 'power plant sites'. With little marketing undertaken SMUD has been adding about 100 PV Pioneer I systems each year.

Finding customers willing to pay has not been difficult for SMUD. PV Pioneer marketing normally consists of just one or two bill stuffers a year, door hangers in neighbourhoods with a predominance of 'good roofs', and as a result free media coverage.

6.1.2. The 200 roofs programme of HEW in Hamburg

Within the 'Hamburger Solarkonzept' in 1997 in total 200 PV systems with an overall capacity of 350 kWp has been installed on private roofs (Haberland and Stuhlweissenburg, 2000). In this programme the municipal utility of Hamburg HEW has rented 200 roofs to install these systems. Over 10 years the roof owner gets 10%

additional ownership of the PV system every year. This is the rent the utility pays for the roof. The total project costs were 5.5 million DM (2.25 million €).

An additional feature of interest within this programme was the fact that HEW launched an EU-wide call for tenders to purchase these 200 PV systems. Finally, four PV suppliers delivered these 200 systems.

6.2. Shareholder programmes

Another concept that has attracted attention mainly in Germany is to sell shares of a PV plant to private customers in blocks of e.g. 100 W. Within this type of programme the customer becomes a shareholder in a renewable power station. At the end of every year he gets back the money generated due to his share. Such programmes have been conducted by utilities, others by other entities (e.g. Salvamoser in Freiburg, IBC/Möhrstedt in Staffelstein, and the so-called PV-associations in the Netherlands. An early example for this programme type is the ‘Bürger für Solarstrom’ — Model of the ‘Bayernwerke’. Table 6 provides some features of some programmes.

An example of a successful privately organised shareholder programme is the ‘SONNENSCHEIN’ campaign launched in the Austrian province of Vorarlberg in 1997. The German word ‘SONNENSCHEIN’ has two meanings: it means sunshine and solar bill. Up to now about 100 kW of decentralised systems has been installed. About 2300 shareholders have raised around 5 Mio. ATS (≈400.000 EURO). This programme is still ongoing.

The programme is coordinated by the ‘Energieinstitut Vorarlberg’.

- Within this programme private individuals and local governments are encouraged to purchase ‘Sonnenscheine’ (= ‘sun bill’).
- The price of a share is 1000 ATS (≈70 US$, ≈70 EURO).
- The systems are operated either by private persons or communities. One of the systems is in Belarus.
- Comprehensive information campaigns, technical tours, and education activities accompany the programme. Moreover, frequent meetings of shareholders and operators ensure that the campaign is kind of a public event.
- The shareholders may cash the money earned from electricity generation at the end of every year or they may donate it into a fund for further PV investments in the education sector.

The installations are supported by means of 30% to 35% rebates from the province of Vorarlberg.

6.3. Contribution programmes

Within contribution or donation programmes customers can donate to a fund for renewable energy projects. On contrary to shareholder programmes within this type of programme the consumers do not get any money back! Most often these funds

Table 6
PV shareholder programmes

Utility	Programme name	Time period	Costs ($EURO/W_p$)	Total number of participants	Participation rate (%)	PV capacity installed (kW)	Money raised per participant (EURO)	Status
Bayern-werk	Bürger für Solarstrom	1994–96	6.63	101	0.01	50	3290	OFF
Konstanz	No	1995–97	7.29	200	0.57	63	2300	OFF
München	Pasinger Fabrik	1997–98	6.76	70	0.01	37	3573	OFF
Freiburg	REGIO	1994–current	N.A.	278	N.A.	208.1	N.A.	ON
Detroit Edison	Solarcurrents	1996–2000	6.59	300	0.3	55	110 US$/year	ON
Vorarlberg	Sonnenschein	1997	N.A.	2300	N.A.	100	150	ON

Source: own investigations, Taus (2001).

are managed by electric utilities. It is an approach which focuses mainly on the promotion of PV systems in public places e.g. schools. The projects developed are unrelated to the customers electricity usage. Usually school projects (see section 12.4.1) rely fully or for a certain percentage on contribution. An example for such a project has been achieved by WPSC in Wisconsin (USA) for schools.

6.4. Utility bidding

To ensure that the most efficient and cheapest PV systems are promoted some utilities have launched a bidding procedure for PV electricity from private generators. This approach has been applied by the utility BEWAG in Berlin in Germany. Every three months from April 1997 until December 2000 there had been a call for tender of PV systems of different size categories.

By December 2000 a total of 635 systems, with an overall capacity of 3345 kWp, had been approved (see Fig. 14). Yet, only 1063 kW has been installed. The average rebate provided by BEWAG was about 3200 Euro/kWp (6375 DM/kWp). Moreover, an additional feed-in tariff of 36¢/kWh (0.72 DM/kWh) was paid (source: BEWAG, Photon 3/2001).

6.5. Bulk purchases

In a bulk purchase programme an organisation e.g. a municipal utility purchases a large amount of PV system at a cheaper per kWp price if every single system would be purchased individually. Two programmes has so far becom popular: The programme of the Stadtwerke Munich in Germany and the PV pioneer II programme of SMUD in California.

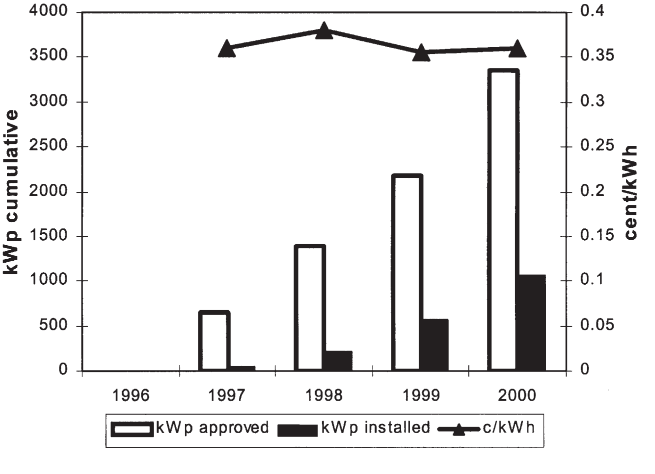


Fig. 14. PV approvals and installments within the PV bidding programme of the BEWAG in Berlin (Germany).

6.5.1. Stadtwerke Munich (Germany)

The first bulk purchase programme of PV systems has been launched in Munich in Germany in 1996. The Stadtwerke Munich purchased about 200 do-it-yourself kits for PV systems with a capacity of 1.1. kWp. and sold it at the same prices to interested programme participants. In total within the promotion programme of the Stadtwerke Munich about 520 kWp were installed on 225 single systems. The average price was about 14 800 DM/kWp (7300 EURO/kWp) which was very cheap at that time.

Moreover, the programme consisted of a mix of very different strategies. Over the first two years accompanied RBIs of about 2 DM/kWh were available. Another initiative was the shareholder programme ‘Pasinger Fabrik’ (see section 9.2).

6.5.2. SMUD’s PV pioneer II programme

Under the slogan ‘Own a piece of the sun and watch your meter turn backwards! ’ SMUD has launched its PV Pioneer II Programme in 1999. It started offering customers a way to own their rooftop solar power plants. The PV Pioneer II systems are owned by the customer, and SMUD ‘buys down’ the cost of the systems bringing the cost to the customer down to where it can compete in the retail market. By bringing down the cost of the PV system to about US$2.50 to US$3.00/W the resulting effective cost of PV electricity is in the competitive range in the California residential electric market when financed in a home mortgage.

The customer’s cost in 1999 to buy a typical 2000 W system is under US$ 5000 (US$ 2.37/W). This system would provide a little over half on the annual energy needs of an average SMUD customer. The full turnkey cost, including utility transactional costs and overhead, of the system to SMUD in 1999 was under US$ 10 000, so the SMUD buydown in 1999 was about 50%.

The second phase of SMUD’s PV programme will bring the fully installed cost to below US$ 3 per installed watt (US$ 3/W) in 2003, placing PV at a point where it can start to become economically interesting. By 2003, the customer cost for a new system will rise to US$ 2.80/W while the cost to SMUD reduces to under US$ 3/W, resulting in a buydown of less than 20¢/W and leading to a sustainable, unsubsidized residential market.

7. Green pricing — voluntary generation-based financial incentives

Under this type of programme usually called ‘green pricing’ utilities or other companies sell electricity generated from renewables at a higher price and take this premium to provide financial incentives for a PV generator. The incentive is paid by the green customer per kWh. Of course, it is also possible, that the utility itself is the generator.

7.1. Green tariffs

The major feature of this type of financing programme is that participants pay a special price premium per kWh over regular rates. This type of financing programme

has gained attention up to now in Switzerland, Germany, Australia, the USA, Austria and The Netherlands. Within this programme type utilities offer ‘green’ electricity — that is to say, electricity generated by wind turbines, biomass, small-scale hydro and PV — at a price that by and large meets the generation costs.

In recent years, labels have become more and more important to prove the content of the product. Green tariffs with respect to PV are most important in Germany, Switzerland and the USA. In Australia a wide variety of Green tariffs exist and most utilities have installed some PV, although it is typically a very small portion of total green power requirements (see e.g. Weller 2000).

With respect to the promotion of BIPV systems it has to be stated that mostly larger plants are built from the revenues of the ‘green tariff’ programmes.

Table 6 describes the major features of the so far most popular worldwide green tariffs in different countries. Only those programmes which contain a substantial amount of PV are listed.

One of the most famous worldwide green tariffs including PV is the ‘Umwelttarif’ of RWE in Germany. As can be seen from Fig. 15 until 1999 about 1 MW of PV capacity has been installed. Yet, since 1998 there is a deadlock. No more capacities were triggered and the number of participants went back from 15 800 in 1998 to 12 500 in 2000, see Fig. 16.

7.2. Solar stock exchange

Another idea of providing financial incentives for the construction of PV systems is the so-called ‘solar stock exchange’. The idea is that electricity is generated by privately-owned PV systems and fed into the public grid. Other customers may buy this electricity and pay rates corresponding to the PV production costs. On the supply-side only the most cost-effective projects are selected by a bidding process.

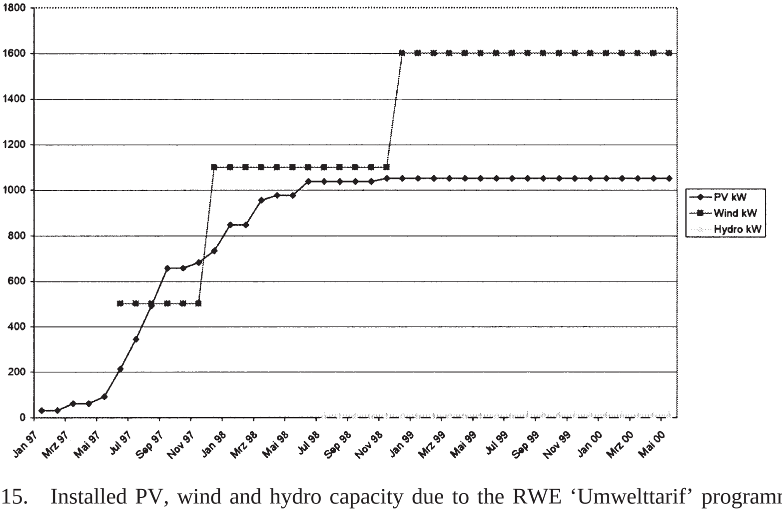


Fig. 15. Installed PV, wind and hydro capacity due to the RWE ‘Umwelttarif’ programme.

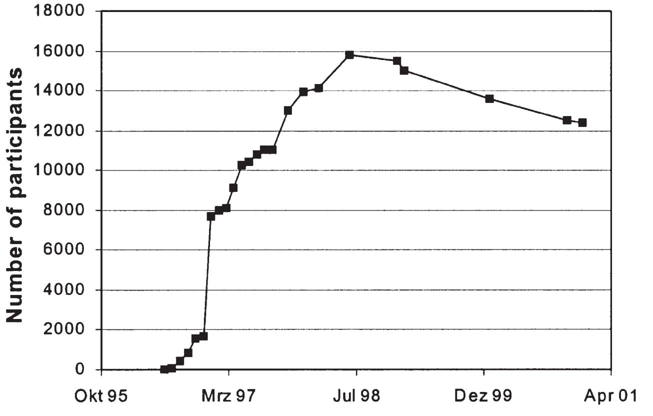


Fig. 16. Number of participants in the German RWE 'Umwelttarif' programme.

The utility acts as a 'power exchange'. That is to say it organises the balance between supply and demand. It launches calls for tenders for new PV capacities and signs long-term contracts with the generator. On the demand-side marketing activities are conducted and the customer may subscribe on a yearly base or longer, see Fig. 17. Usually, the utility bears the administration costs but has no other expenses. The customers choose how much solar electricity they want to buy. The minimum order is usually 100 kWh/year. The price is around 60–65 c/kWh (0.95 and 1.15 sFr/kWh) in 2001. It has to be recognised that the system costs and the price for customers has decreased continously since 1996 (from about 1.40 in 1996 to 1 sFr/kWh).

The advantages of this strategy are:

- customers WTP is fully exhausted;
- efficient operation is ensured;
- private 'green' PV owners ensure that only the best examples for PV will be constructed;

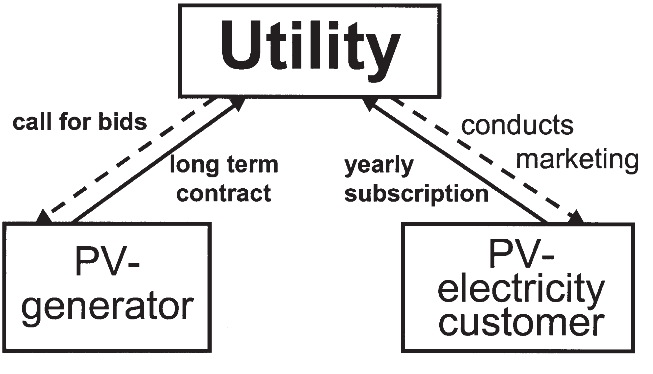


Fig. 17. The principle of the 'Solarstrombörse' applied by various utilities in Switzerland.

- kind of a ‘green label’ with high credit (‘pure solar electricity’) may be associated with this type of strategy.

This idea was first developed for the city of Zurich in Switzerland by the municipal utility ewz. At the end of 2000 about 1.7 MW had been installed, see Fig. 18. The target was to reach 2.4 MW by the end of the year 2000. [13] and Homepage ewz).

Of special interest is also the marketing strategy applied by ewz. The single solar systems were named by famous stars and a so-called ‘Züricher Sonnensystem’ was created, see Fig. 19.

The programme has also attracted attention in other cities. More than half of the Swiss population has access to ‘Solarstrom’. Some examples and their major features are described in Table 7.

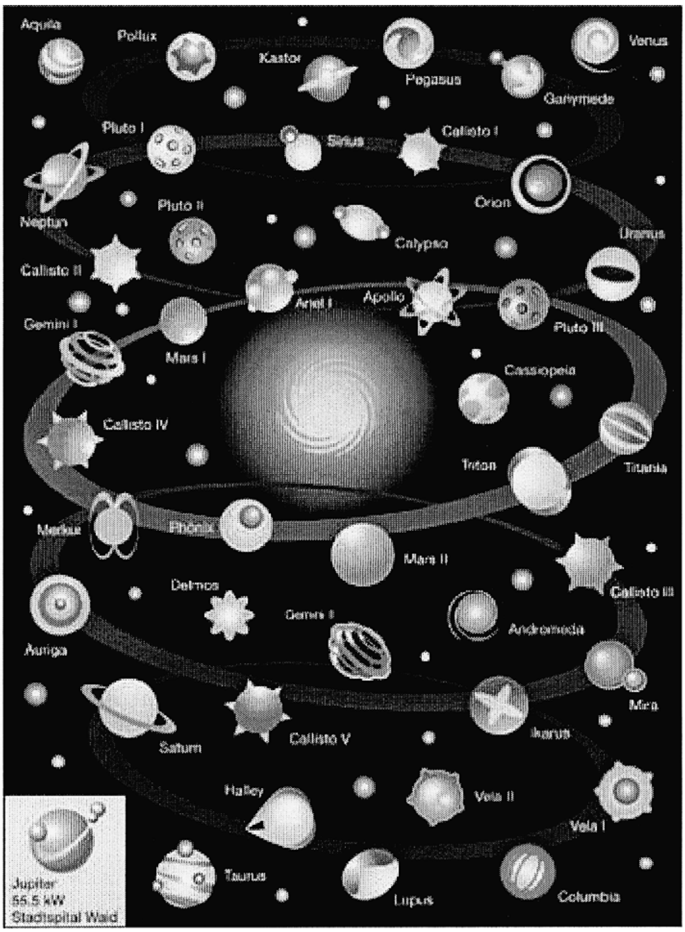


Fig. 18. PV installations within the ‘Solarstrombörse’ programme of the ewz in Zurich (Switzerland).

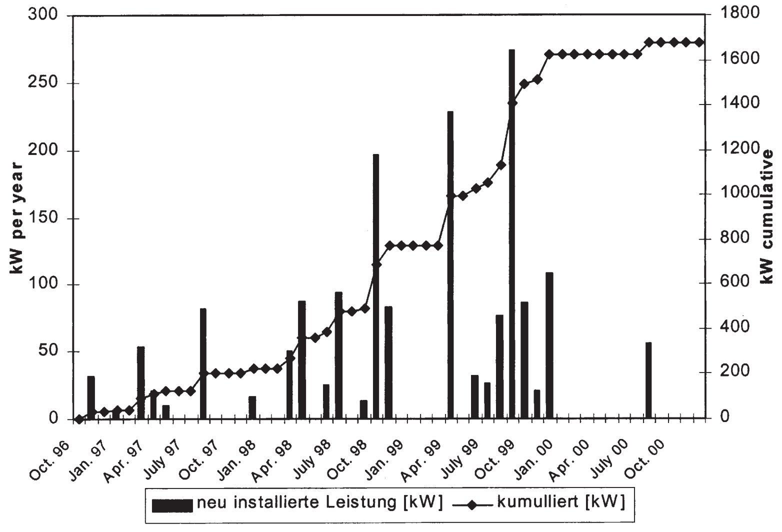


Fig. 19. Marketing approach of 'Solarstrombörse' programme of the ewz: 'Creating a 'Zuericher Sonnensystem' .

A remark with respect to the system size: It has to be stated that mostly larger plants are built from the revenues of the 'Solarstrombörse'.

7.3. Green power marketing

In the age of fully liberalised electricity markets in many countries Green electricity suppliers have emerged. That is to say, under green power marketing a private or commercial or industrial customer may change their supplier and switch to a company which provides a certain brand of green electricity. In different mixes a certain amount of PV is required.

Of course this approach is potentially interesting for development of PV. There are some German ones (Naturstrom, Unit[e]), Green Mountain in the USA, 'Echte Energie' in The Netherlands.

According to Swezey and Bird (2000) in the USA by the end of 1999 a PV capacity of 268 kWp has been added due to green power marketing in states with fully liberalised electricity markets.

7.4. The Dutch green label proposal

A tradable 'green labels' market has already started as of January 1998. Under current laws, local energy distribution companies (LEDCs) must purchase renewable electricity from independent power generators at a price determined based on the current market price of electricity and the regulating energy tax refund. However, under the new programme, in addition, the LEDCs must issue green labels to the renewable generator based on the number of renewable kWh sold to the grid (one

Table 7
Some examples for Solar Stock Exchange models

Utility (country)	Start date	Price for customers sFr/ kWh	Number of parti-cipants (year)	Partici-pation rate	Total PV capacity installed (kW)	PV electricity delivered (MWh/yr)	Money raised per participant	Status
EWZ (CH)	1996	1.20 (1996) 0.95 (2000)	5 700(2000)	3.2	1680	1021	120 sFr	ON
EKZ (CH)	1997	1.20 (1997) 1.05 (2000)	2 600(2000)	1.4	281	477	140 sFr	ON
EWB (CH)	1997	1.20 (1997) 0.88 (2000)	3 200(2000)	2.5	723	630	150 sFr	ON
CKW (CH)	1998	1.0 sFr/ kWh	176(2000)	N.A.	N.A.	40	180 sFr	ON
FÜW (D)	1998	1.40 DM/ kWh	240(2000)	N.A.	29	23	134 DM	ON

Source: Daniel Ruoss, personal information and Internet-Homepages of the companies.

green label represents 10 000 kWh of renewable electricity). The renewable generator can then sell these green labels on an open market to distribution utilities who will all be required to own a certain quota of green labels as part of their agreement with the government. With wind energy, for example, given current production costs of *ca* 0.16 NLG/kWh and current payments from utilities of *ca* 0.11 NLG/kWh, the renewable generator would have to sell its green labels for at least 0.05 NLG/kWh to realise a profit.

This mechanism is similar to the RPS mechanism proposed in the USA and essentially reserves a certain percentage of the electricity market for renewable energy within an otherwise liberalised market. However, unlike the RPS, the Dutch green labels scheme guarantees that all renewable generators can sell power to the grid at an assured price, thus removing some of the market uncertainty of the RPS but simultaneously perhaps reducing the economic incentive to reduce renewable energy costs.

8. Other strategies

As well as the important strategies and corresponding programmes described in previous sections various other types of strategies have also been applied. Despite tthe fact that there are no clear lessons yet learnt from these strategies they are documented in the following to complete the picture.

8.1. NGO initiatives

Aside from green tariffs private shareholder and donation projects have been launched by different other types of organisations e.g. NGOs. The most important programmes are summarised in this chapter.

8.1.1. The SOLARIS programme

A successful example is the SOLARIS programme launched by Greenpeace in 1997 in The Netherlands. The overall objective of Solaris is to realise 20 000 AC-modules on residential houses. The first phase of 5000 AC-modules started in August 1999. Within this programme by the end of 1999, about 3000 AC-modules had been installed and about 15 000 applicants has registered (Major references: Schoen, 2000; de Wit et al., 2000).

The AC-modules (100 Wp modules) are offered as do-it-yourself packages for € 442.50 (975 NLG) with a maximum of four AC-modules per address. This low price, which is about half the normal price, can be realised by purchasing the modules on a large-scale and by using subsidies from both the Dutch government and utilities and by applying favourable tax regulations. Within this programme no financial incentives are provided for residential customers! Only for commercial companies subsidies were available (25% by the Dutch government). As a consequence of the use of these tax regulations, the AC-modules are offered for (operational) lease and not for sale.

The prices mentioned are net prices, in which subsidies and tax benefits have already been discounted.

The Solaris project is the first large-scale marketing campaign on the consumer market in Europe, carried out by commercial partners. It is therefore a unique project to gain experiences with marketing concepts for renewable energy.

The use of an (operational) lease construction is very new for The Netherlands and unique for Europe. An advantage of the lease construction is access to favourable tax regulations. Lease constructions therefore offer great possibilities for the financing of PV-systems, not only for private consumers, but also for e.g. public institutions.

8.2. Commercial financing programmes

Here financing programmes launched by commercial companies are summarised. So far worldwide it is not possible to attribute specific PV installations to this type of strategy. Hence, the initiatives/programmes described in the following should mainly serve to provide ideas of what might be possible in the future and to complete the documentation of possible strategies.

The most important countries with respect to private financing are the USA, Japan, the UK, Switzerland, Germany and The Netherlands.

The USA is undoubtedly the country with the largest number of private financing models. For details see The Borrower's Guide to Financing Solar Systems' (DOE, 1998) and Eiffert et al. (2001).

In Japan some financing institutes such as banks provide preferential financing at low interest rates for residential PV systems for private use.

Insurance companies are involved increasingly in Switzerland, Germany and the UK, e.g. Swiss RE, Münchner RE and suppliers like Solar Century in the UK.

So far it is not possible to appraise the effects of these financing activities on the dissemination of PV systems.

8.3. Retailer alliances

As has been mentioned under barriers there are a lot of problems with respect to providing an adequate infrastructure and a guaranteed technical reliabilty as well as service level on the PV retailer side.

Two types of strategies are currently applied to cope with these problems: Franchising and guaranteed yields programmes.

In Germany, franchising for PV systems has attracted attention in four retailer groups: Sunlive, SunTechnics, Solar Direct and Solarvent. More than 100 PV retail companies have been involved by the end of 2000.

Another idea is to provide a guaranteed yield.

Yet, so far for both types of strategies no performance data are available.

8.4. Public building programmes

If the added values of a technology like PV are recognised by society — that is to say by local or national governments or NGOs — it is very important that their relevance is emphasised by integrating them in public buildings. Indeed, various programmes focussing on different types of public buildings such as schools, town halls and churches have been conducted in various countries, mainly in Germany.

8.4.1. School programmes

In various countries strategies have been launched by governments or electric utilities to provide PV for schools. Especially in Germany a wide range of activities has taken place. Utilities like Bayernwerke (now E.ON), BEWAG, HEW, Preussen-Elektra (now E.ON) have promoted >1000 PV systems on schools. Also the German ministery for Economic affairs has launched a large programme supporting >200 schools.

In the UK the ETSU supports a similar school programme called SCOLAR. The programme was for a maximum of 100 schools, 95 applications were approved before the closing date, but a number of these failed to be implemented for one reason or another (matching funding, timing, etc.) so the final count is expected to be 73 systems. All but seven are now installed and the programme closes soon[2].

In the USA school programmes are mainly funded by contribution funds. In the USA the UPVG is monitoring solar initiatives of schools nationwide through its ‘Schools going Solar’ campaign supported by the DOE. So far ‘schools going solar’ encompasses around 50 projects.

As an example the German project SONNEonline is described in more detail. The project was launched in 1997 by Preussen-Elektra (Now: E.ON) and 31 local energy utilities in Northern Germany. Its intention was to introduce PV to schools. Standardised construction kits of 1 kWp were installed in about 400 participating schools in Northern Germany up to the end of 2000. The schools were responsible for a financial contribution, the assembling and operation of the PV system and the monitoring and data transfer via internet to FhG/ISE in Freiburg. The ISE organised the storage and the evaluation of the data. In addition to the PV system the schools received a PC and internet access. So the pupils are able to communicate with all other SONNEonline operators allowing a detailed exchange of their system results and general experience with PV.

The programme is completed. It was limited to these 400 schools. The interest was by far higher. More than 1000 applications were received. A major reference is Skorka et al. [14]. More information is available at www.sonneonline.de.

A summary on some important schools programmes worldwide is provided in Table 8. Further reading: Hoffmann (2000) and Kiefer et al. [15].

[2] Reference: Donna Munro, personal information.

Table 8
Some examples for promoting PV in schools (source: Kiefer et al. [15], Swezey and Bird (2001))

Project name	Time period	Number of systems	Average system size (total)	Average yield	Financial support	Supported by	Status
Sonne in der Schule	1994–1997	544	1.1 kWp (610 kWp)	n.a.	60%	Bayernwerk (DE)	OFF
SONNEonline	1997–2000	405	1.1 kWp (500 kWp)	693 kWh/kWp	60%	PreussenElektra (DE)	OFF
Sonne in der Schule	1998–2001	320	1 kWp (350 kWp)	763 kWh/kWp	3000 EURO/system (6000 DM/system)	BMWi (DE)	ON
SCOLAR (UK)	1998–2001	73	1.1 kWp (80 kWp)	N.A.	60%	ETSU (UK)	OFF
PSCO	1998–2000	30	1.8 kWp (52.8 kWp)	N.A.	Contribution programme	PSCO Colorado, USA)	ON
SolarWise for Schools	1996–2000	10	4.8 kWp (50 kWp)	N.A.	Contribution programme	Wisconsin Public service (USA)	ON

8.5. Promoting green buildings

Finally, an important group which may act as a transmitter are building construction companies. They may support PV if the system is integrated in a 'green' building. There are some nice examples from the Netherlands and Germany.

In the Netherlands WWF buildings, which asked for a limited amount of PV on green buildings, have raised attention.

In Austria and Germany some prefabricating home manufacturers (e.g. 'Hartl'-Haus) offer buildings with PV integrated.

In Australia, 640 energy efficient houses near the Year 2000 Olympic venue were constructed with building integrated PVs.

In Japan housing companies make use of the residential rebate programme. They are promoting the sales of products with the PV system as standard equipment (Ikki, 2000).

Summing up there are various intiatives which support green buildings, 'Passivhäuser', etc, which have a positive impact on the market for PV.

8.5.1. '50 Solar energy housing estates in NRW'

A special project of interest is currently under way in in NRW in Germany. In 1997 the state initiative on future energies NRW launched the '50 Solar energy housing estates in NRW' concept. The objective of this programme is to support and supervise the construction of solar houses[3]. The buildings within this programme has to meet two of the following three requirements:

- very high thermal insulation standards;
- integration of a PV system; and
- integration of solar thermal systems.

Some projects are already completed others are still under construction. So far especially the following three projects have attracted attention with respect to the role PV plays:

- a new built settlement in the city of Gelsenkirchen where two building construction companies has contructed and sold solar houses;
- retrofit of 548 dwellings in multi-family-houses in Köln-Bocklemünd. All of these buildings were also equipped with PV systems; and
- a settlement in Bielefeld where houses were marketed individually. Yet, PV systems were required to be integrated in the buildings envelope.

9. An evaluation and review of various strategies

In this section it is finally discussed which of the programme types presented above were successful and which strategies are most promising for the future.

[3] For updated information visit: http://www.50-solarsiedlungen.de.

Of special interest is the difference between regulatory and voluntary strategies on the one hand and between strategies focussing on investments and strategies focusing on payments per kWh (‘regulated rates’) on the other hand.

With respect to voluntary national target programmes both programmes launched so far without substantial financial incentives has been successful. The Dutch programme surpassed its first goal of 7.7 MW in the year 2000 and in Switzerland about 15 MW of the goal of 50 MW was attained by the end of 2000.

Rebates are in general an effective tool to enhance the market penetration of PV in a nascent market. Moreover, rebates are an important instrument to ensure a maximum of own use of decentralised PV electricity.

Of the three types of regulated rates applied in various countries in recent years RBIs (e. g. enhanced feed-in tariffs) turned out to be the most successful tool for achieving a significant increase in market penetration. Virtually all programmes based on regulated rates close to the production costs and guaranteed over a period of about 15 years were successful.

The major advantages of RBIs are:

- they are effective in the sense that they trigger substantial installations of new PV systems;
- they ensure technically efficient operation of the plants; are
- regulated rates are preferable to rebates with respect to system performance and lower transaction costs and bureaucracy.

On net metering no sound results regarding their effect on increasing the market share of PV are available. Net metering may be considered as a minimum condition for the acceptance of PV in a utilities network and it is a correct instrument to encourage a maximum of own-use of PV electricity. Net metering is a successful strategy if it is accompanied by financial incentives on the investment and comprehensive marketing activities Yet, if net metering is not accompanied by other financial incentives in general it does not really foster the market penetration of PV.

The most promising strategy under the voluntary capacity-based programmes are green shareholder programmes. These are usually very successful as a first step of market introduction in a local area. The installed capacity is limited by the WTP to buy shares. If such a strategy was to be launched in every village or neighbourhood in a country it would lead to a substantial increase in PV capacity. The programmes implemented so far have been especially successful if they were accompanied by social events.

Green tariffs and solar stock exchanges are based on a high consumers’ WTP for ‘green electricity’ and trust in the seriousness of the ‘old’ incumbent utility. Hence, they depend very strongly on the credibility of the organisation that offers it. Effective green pricing programmes have to exhaust electricity consumers’ WTP for ‘green electricity’ as far as possible. In general green tariff programmes need a lot of public relations work from the utility to make them work (see e.g. the RWE programme in Germany or the ewz ‘Solarstrombörse’ in Switzerland). Most important is that they are accompanied by a credible green label.

A new strategy in a liberalised market is green power marketing. Experience so far tells us that, as with green pricing for PV, it is only promising if it is accompanied by an attractive and credible green label. this means the label must guarantee a certain amount of PV from new installations.

Recently launched NGO initiatives have been surprisingly successful. They proved that there is a high WTP of private customers if a strategy is launched by an organisation with high environmental credit.

10. Conclusions

This review of market deployment strategies for SGCSs shows that there is a wide range of possibilities to increase their market penetration and that there are real success stories. Yet, there are considerable differences in these strategies with respect to technical and economic efficiency as well as with respect to their success in triggering a substantial number of new installments. In the following the most important conclusions of this analysis are reported.

Regardless which strategy is chosen the following basic requirements apply.

- Comprehensive accompanied information and education activities are important.
- High environmental credibility of the institution/company which launches a voluntary strategy based on customers WTP (e.g. green pricing or a solar stock exchange) is a very important precondition.
- Predictability and continuity over time is of tremendous importance. Avoid ‘stop and go’ strategies! It has to be clear how long a policy will last to provide confidence among customers and the PV industry!
- It has to be ensured that after the programme is terminated a sustainable development of the PV industry is likely and that the market does not collapse.
- The design of a PV strategy should allow the rejection of projects that are unlikely to be good examples and encourage suppliers to improve the operational performance and technology efficiency.
- It is important to note that efficient promotion programmes take into account consumers’ WTP. Optimal financial incentives would provide only the difference between the system costs and the WTP for PV. The incentives in most programmes up to now were not optimally designed. Consumers WTP for PV is higher than expected by programme designers. With the same amount of total subsidies it would have been possible to promote more PV systems.
- With respect to financial incentives it is of tremendous importance that they show a decreasing characteristics over time and that they are designed dynamically. That is to say financial incentives have to be reduced over time to an extent which is justified by societal benefits.
- When designing a programme it should be borne in mind that there are the following important areas of activity: the PV customer, the PV market, the technology, society and communication between the former.
- An important issue in this context is also international dissemination and inter-

national learning. In some countries more progress has been made than in others. The maturity of markets is different in different regions.

Finally, it is stated that to be successful, it is of paramount importance to design strategies in a way where governments, the PV industry, utilities, NGO's and potential investors co-operate. If this cooperation takes place in a constructive way with goodwill from all participating parties it may in some years lead to the vision of electricity supply where the added values of all renewables for electricity generation are fully reaped and provides the utmost benefits for society.

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